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REMOTE SENSING IN HAZARDOUS WASTE SITE INVESTIGATIONS AND LITIGATION

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ABSTRACT

This report describes how remote sensing and its associated products can be used in hazardous waste site enforcement investigations and subsequent litigation. The report includes a discussion of foundational material on aerial cameras, film, resolution, photo interpretive process, and photogrammetry. Emphasis is upon aerial photographic uses as contrasted with digital imagery applications. Photo products and their usage, specifically, photo contacts and enlargement prints, and photo analysis and topographic map data are discussed. Typical enforcement project phases of project request, background review, project plan, project activities, final report, and follow up are reviewed in light of aerial photographic needs. Eleven examples of actual U.S. Environmental Protection Agency (EPA) enforcement investigations or legal cases are presented. Conclusions state that usage of aerial photos can increase the amount of site information derived from an investigation and presented in a courtroom setting. Efficiency of field operations is also enhanced through use of aerial photography.

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SECTION I
INTRODUCTION

The handling or disposal of hazardous wastes may result in pollution of the land, air, or water, or endanger human health. In order to prevent these problems, it is important to know who generates and handles hazardous wastes and when, where, and how these activities take place. Likewise, knowledge of the location and extent of environmental impact of old, abandoned waste disposal sites is necessary to effectively assess, monitor, and assure compliance to legislation.

Under the authority of the Resource Conservation and Recovery Act (RCRA) of 1976 and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, the EPA is responsible for identifying, assessing, monitoring, and controlling all hazardous waste storage and disposal operations within the United States. In addition, the Agency must identify and analyze all uncontrolled hazardous waste sites. State and local agencies and authorities collaborate with EPA in accomplishing these tasks.

As EPA and state officials identify either active or abandoned sites where hazardous wastes are stored or disposed of, assessments must be made of the types of wastes; methods of containment; possible contamination of air, soil, and water supplies, and pollutant pathways via surface waters at each site. When assessments are completed, maintenance, removal, or remedial plans are developed to assure safe management or detoxification of sites. Conflicts may arise between site owners or waste depositors and EPA regarding culpability, financial obligations, or other factors and thus require EPA to initiate enforcement actions. Since information acquired in enforcement assessments or investigations may eventually be used in litigation, it must be thorough, comprehensive, and timely.

Remote sensing and its products can play a major role in enforcement investigations and litigation. The imagery and its products possess certain qualities and have certain uses that make their inclusion in enforcement investigations and litigation desirable. Some of these qualities and uses are:

- A synoptic view of investigated sites
- A permanent record of environmental conditions
- Legal evidence in courtroom proceedings
- Exhibitions for briefings and expert witness testimony

This report describes how remote sensing and its associated products can be used in hazardous waste site investigations as a prelude to more expensive field investigations, enforcement investigations, and litigation. The report includes descriptions of remote sensing products, their uses, and actual EPA investigations in which remote sensing data were used. The information contained in this report will assist EPA and state personnel in using such products to perform initial site investigations, comprehensive enforcement studies, and displaying results in courtroom settings. This report was revised in December of 1988 under project # TS-AMD-89738.

SECTION II
SUMMARY AND CONCLUSIONS

SUMMARY

In response to the magnitude of the hazardous waste management problem in the United States, RCRA and CERCLA legislation was passed in 1976 and 1980, respectively, authorizing EPA to identify, assess, monitor, and control transport and disposal of all hazardous materials and identify and analyze all uncontrolled hazardous waste sites. Remote sensing techniques are used early in the process to identify potential sites and to provide information used in planning subsequent investigations such as geophysical surveys and drilling. Information gained through remote sensing techniques is also useful in evaluating or interpreting data from other sources. In discharging its responsibilities, EPA at times experiences conflicts regarding culpability, financial obligations, and other factors that often require enforcement action and eventually litigation. Remote sensing techniques and products also play an important role in these enforcement investigations and litigations.

This report describes how remote sensing techniques and products can be used in hazardous waste site investigations, enforcement investigations, and subsequent litigation. Products and their uses are described and actual EPA investigations in which remote sensing data were used are discussed.

Basic information regarding aerial photography is given. Since no examples of use of digital imagery in hazardous waste enforcement investigations could be found, the emphasis of this report is on use of aerial photography. An in-depth discussion of digital imagery and its applications is given in "Overhead Remote Sensing for Assessment of Hazardous Waste Sites," EPA Report 600/X-82-019 dated November 1982. A description of aerial cameras, films, and aerial photo resolution are also discussed.

The photointerpretive process involves a recognition of certain image characteristics. Combinations of these characteristics form "signatures" which are unique to each photo. Photogrammetry, which is the science and technology of measuring physical objects and their spatial relationships from photographs, can be used to produce special topographic maps which have a number of uses in hazardous waste enforcement investigations.

Photo prints or enlargements can be used for field work, office and public briefings. Stereoscopic analysis of aerial photography can give the site investigator additional information in conducting a wide variety of studies including remedial investigations, feasibility studies, site characterizations, and enforcement studies. Information extracted from photos can be general in scope such as surface drainage network delineations, or intensive involving the locating of pits, ponds, lagoons, burial areas, and other significant features on historical and current photos. These data can be used to corroborate an informant's information, assess impacted areas, trace offsite pollutant transport pathways, observe past and present activity, aid in design of ground sampling plans, and illustrate site violations at briefings. Special topographic maps have several uses such as: estimates of amounts of soil overburden needed to be removed during site remediation, determination of flooding potential, and assessment of adequacy or inadequacy of dike or impoundment containments. Displays of photo prints (photo mosaics), Landsat and Thematic Mapper imagery, and U.S. Geological Survey (USGS) or EMSL-LV topographic sheets can be compiled for field use, planning, formal briefings, courtroom, and other uses.

Each hazardous waste site investigation progresses through certain phases. For example, EPA's National Enforcement Investigation Center (NEIC) Policies and Procedures book, 1983 (see References) states that these include:

- Project request
- Background review
- Project plan
- Project activities
- Final report
- Follow up

When a project request is prepared, use of aerial photography should be considered. During the background review phase, information is collected for preparation of the project plan. Information needed for inclusion of photos and photo analysis in enforcement projects includes:

- Film type, photo scale(s), and time of photo acquisition
- Specific features to be identified and delineated
- Use of current and/or historical photographs
- Inclusive dates for study period
- Specific dates for historical photocoverages
- Enlargements for field work
- Final deliverables

Collateral input such as published or unpublished data on the physical environment and activities of hazardous waste operations is requisite to conducting the photo analysis study.

The project plan should include schedules for photo acquisition and deliverables. It is essential that all overflights and interim deliverables (enlargements for field work) be completed prior to field work.

Actual project activities in a photo analysis study include aerial photo acquisition, preparation of photo contact or enlargement prints, photo analysis, and final report preparation. Strict chain of custody rules are employed to prevent tampering with photo images or interpreted data.

Results of photo analysis of a site are presented in the final report. All photo features requiring identification by the customer and any additional features thought to be pertinent are also included. The presence or absence of features is traced through the various years of historical photocoverage.

Follow up would include: any additional photos and/or analysis not covered in the final report, long-term monitoring requirements, monitoring of subsequent remedial efforts, and expert witness testimony regarding photointerpretive process and analysis results.

Examples of eleven site investigations using photo analysis for various purposes are detailed. Each is summarized as to the utility of aerial photos or photo analysis in conjunction with information gathered during the actual site/field investigation(s).

CONCLUSIONS

In light of the scope of the hazardous waste storage and disposal problem in the United States and the resulting number of investigations and litigations, all available means should be used to increase the amount of site information derived from an investigation or disclosed in the courtroom. Aerial photographs and subsequent photo analysis can increase efficiency of ground studies/investigations.

Additional information such as location of old solid waste management units, trenches, lagoons, and waste disposal areas and other sources of contamination can be acquired by analysis of historical photographs. Old drainageways, since filled in by site construction, may offer preferential flow for contaminated liquids offsite or into groundwater aquifers. Information gained from current photos can range from simple drum counts, lagoon seepages, and surface drainage delineations to detection of site features not revealed by ground investigations. An aerial photo depicts a synoptic view of each site with correct spatial relationships preserved as a permanent record of environmental conditions at one point in time.

Use of aerial photos as a planning tool can greatly increase the efficiency of field investigations by locating through use of historical photographs, specific areas of contamination within a site which need to be field sampled. Photos can also be used as a base map to plot future monitoring well locations and other features. While field investigations are ongoing, current photos are needed for actual field work, briefings, and status reports.

One of the most important features of aerial photography is that of visual impact. Numerical data and graphs are important, but when spatial data (and numerical, if desired) is viewed on aerial photographic displays, it enhances the understanding of sometimes complex scenarios regarding site development and work processes. This graphic impact can greatly influence decisions by owners, judges, or other interested parties. Out-of-court settlements have been obtained as the result of graphic display of investigative findings.

SECTION III
NATURE AND SCOPE OF THE HAZARDOUS WASTE PROBLEM

LEGAL AND ADMINISTRATIVE FRAMEWORK

Public Law 94-580, the Resource Conservation and Recovery Act (RCRA) was passed in 1976. The law gives EPA responsibility over all aspects of hazardous waste management. These include identification and listing of storage and disposal sites, standards of operation for waste generators and disposers, site inspections, enforcement, and state and local government involvement. The law deals specifically with ongoing hazardous waste operations. However, sites that are abandoned can have equal or greater environmental problems than ongoing operations. Even though RCRA gave EPA some authority over these uncontrolled sites, additional legislation was needed.

In 1980, Public Law 96-510, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or "Superfund" was enacted. It gives EPA power to identify and assess all uncontrolled or abandoned hazardous waste sites. If any of these sites are determined to pose an immediate or long-term threat to public health or the environment, EPA has the responsibility to take action to remove or lessen the threat. To deal with the most severe environmental threats first, the National Priorities List (NPL) was established under Superfund. The prioritization process ranks uncontrolled waste sites as to the seriousness of environmental threat. Sites on the list qualify for remedial or removal funding under Superfund. EPA is also responsible for determining who is responsible for contamination and insuring that responsible parties assist in site cleanup. Also addressed under this law is the detection, cleanup, and subsequent monitoring of hazardous spills incidents.

SCOPE OF THE PROBLEM

The scope of the hazardous waste problem in the United States is immense and far reaching. In 1986 there were approximately 63,000 major hazardous waste generators, 12,500 transporters, and 6,300 regulated treatment, storage, and disposal (TSD) sites. There were also a total of 24,300 CERCLA sites and 850 sites listed or proposed for the NPL, while in 1988 there were 1177 sites listed or proposed for the NPL. Methods for treatment, storage, and disposal include landfilling, waste injection below ground, land farming, surface impoundment storage, and incineration. With regard to hazardous substance spills, EPA's National Response Center received 11,663 such notifications in 1985. This information was obtained from EPA personnel in charge of the Hazardous Waste Data Management System in Washington, D.C. (see references)

SECTION IV

REMOTE SENSING TECHNOLOGY AND PRODUCTS

Before specific applications of the use of remote sensing data can be discussed, a certain amount of technological information should be presented to properly orient the reader. Basic information regarding remote sensing can be grouped into two broad categories; aerial photography and digital imagery. Currently, all of the remote sensing products used in hazardous waste enforcement and litigation are those derived from aerial photography. Therefore, the emphasis of this report will center upon aerial photographs. Following is a discussion of aerial cameras, films, and photographic resolution. A more detailed discussion is focused in "Overhead Remote Sensing for Assessment of Hazardous Waste Sites," EPA Report 600/X-82-019 dated November 1982.

A variety of camera types exist that have been modified in some way for use in aircraft. Included in this category are 35 mm and 70 mm format cameras. Other camera types have been designed specifically for such use. The most versatile and widely used is the 9" x 9" format mapping camera. It is designed to produce extremely high geometric quality photographs and is the type of camera typically employed for acquisition of hazardous waste site photography.

There are basically four types of aerial photographic films. These are black-and-white panchromatic, black-and-white infrared, natural color, and color infrared. Black-and-white panchromatic faithfully reproduces geometric image characteristics of shape, size, and shadow as well as depiction of image features in shades of gray. One of its largest uses is by the U.S. Department of Agriculture as a planning tool for various types of field surveys. Another prominent use is for topographic map compilation. It is not ordinarily used for hazardous waste investigations because color photography allows photointerpreters to identify and delineate a greater number of site features. Black-and-white infrared film records wavelengths within and beyond the human range of vision. It is used in forestry work because it produces tones that allow interpreters to differentiate between hardwood and coniferous trees. It also produces good definition of land/water interfaces and soil moisture conditions.

Natural color aerial film portrays a photographed object much as it would be viewed by the human eye. This film type has a number of uses by private and public agencies and is extensively used by EPA for hazardous waste site investigations. Color infrared film, like its black-and-white counterpart, is sensitive to infrared wavelengths. Vegetation is seen in varying shades of red. If vegetation stress or damage is suspected at a hazardous waste site, this type of film could be used in conjunction with color photographs to document such damage.

Aerial photographic resolution, expressed in photointerpretive terms, is the ability to distinguish two closely spaced features from each other at a given photo scale. Thus, photo resolution varies directly with scale. Other factors are involved but the greatest factor in the degree of resolution is scale of the photography. The larger the scale, the greater the resolution, that is, the photointerpreter can identify and delineate more objects on the photograph. When planning a photo mission, great care must be given to determination of photo scale. To correctly assign a photo scale the photointerpreter must determine from the user the features that he desires to be identified.

PHOTOINTERPRETATION AND PHOTOGRAMMETRY

The use of aerial photography began in the mid 1800's, but it did not come into wide use until World War II when photo interpretation produced information on troop positions and strengths. Since that time, use has spread to disciplines such as engineering, cartography, forestry, geology, and other earth sciences. When the photographs are analyzed by photo interpreters trained in these disciplines, a methodology known as the photo interpretive process is employed.

Photo analysis or photo interpretation is a deductive process whereby photo features are identified by recognition of a combination of image characteristics such as size, shape, tone, texture, and shadow. Combinations of these image characteristics form "signatures." These signatures are unique to each photo feature. Recognition of these "signatures" enables identification of photo features.

Photo analysis information can be of great value to hazardous waste investigators, especially when multidate photographs are used. The Advanced Monitoring Systems Division of EPA's Environmental Monitoring Systems Laboratory in Las Vegas, Nevada, prepares site assessment reports using interpreted photo products.

Photogrammetry is the science and technology of measuring physical objects and their spatial relationships from photographs. Through use of aerial photographs and precise ground surveys, maps are produced displaying ground features in their correct planimetric (two-dimensional) and topographic (three-dimensional) relationships. Examples of these maps are the 7.5- and 15-minute topographic quadrangles produced by the U.S. Geological Survey. Special topographic maps produced for hazardous waste sites can have a number of uses in an investigation. For a more detailed discussion of aerial photographic interpretation and technological topics, see EPA Report 600/X-82-019. "Overhead Remote Sensing for Assessment of Hazardous Waste Sites," November 1982.

PHOTOGRAPHIC PRODUCTS AND THEIR USAGE

Photographic Prints

A variety of products can be produced from private or public groups having the capability to collect and analyze aerial photography. The most useful product is the photographic print. These prints come in the original film size (9" x 9" contact print) or in any enlargement size up to 20" x 24". Certain private custom labs can produce photo enlargements up to 50" x 100" in size.

Whether an investigator chooses original film size (contact) prints or enlargements would depend on the intended use. Contact prints are somewhat easier to use in the field but may not contain sufficient detail that an enlargement would provide. Enlargements would be the better selection for much field work, office and public briefings, or courtroom proceedings.

Photo Analysis Data

Photo analysis data can give the investigator additional information necessary in conducting an enforcement study. The amount of information extracted from photographs can range from a very general analysis such as identification and delineation of drainage networks to very intensive analysis involving the location of hazardous waste features such as pits, ponds, lagoons, burial areas, standing liquids, and excavations. Tracing of the history of each feature throughout the study period contributes to an overall understand of waste management at each site. This data is usually portrayed clear acetate overlays affixed to the aerial photographs.

Analysis data has a number of uses. Data extracted from aerial photographs can be used to corroborate the validity of an informant's information. In cases where surface water runoff may be contaminated, pollutant drainage pathways can be mapped and environmentally impacted areas ascertained. Simple analysis data such as number of drums present at the site may relate directly to violations. Description of past and present activity at a site can be helpful in establishment of a ground sampling plan and also to illustrate violations for briefings. Location of a site and time of initiation of certain activities can also be established from aerial photography.

Topographic maps (usually on a mylar base material) can depict elevational differences as small as 0.5 feet. These maps can be used to estimate amounts of soil overburden adjacent water bodies needing to be removed and stored when a site is being cleaned up. Flooding of a hazardous waste site may cause transport of pollutants into adjacent water bodies. Flooding potential at sites located in coastal or floodplain areas can be ascertained through use of these maps. The adequacy or inadequacy of the containment of dikes and impoundments or the volume of a mass of earthen material can be quantitatively assessed. Because of the detailed topographic data, tracing of microgradients to identify potential pollutant pathways into adjacent water bodies can also be performed.

In addition to photographic prints and data analysis information, displays of photo prints (photomosaics), Landsat and Thematic Mapper imagery, and U.S. Geological Survey topographic quadrangles can also be constructed for formal briefings and courtroom proceedings. A photomosaic is a series of overlapping photo prints permanently affixed to a board or other display base. These mosaics can depict individual hazardous waste sites or large areas of land directly effected by one or more sites. Display of photo analysis information can also be accomplished through use of clear acetate overlays on the photomosaic. If historical photo analysis yielded information important to a particular case, this data could be displayed in such a manner as to create a scenario of site history. This type of displayed information has very high visual impact both in briefing and courtroom settings.

SECTION V

ENFORCEMENT INVESTIGATION STUDY PHASES

Each hazardous waste site enforcement study progresses through certain phases. NEIC Policies and Procedures book (1983) (see References) states that these include 1) project request, 2) background review, 3) project plan, 4) project activities, 5) final report, and 6) follow up. To illustrate what decisions are to be made with regard to aerial photograph usage and when these decisions should be made, these study phases will be discussed below. It is realized that actual investigative steps within the RCRA and CERCLA programs are different due to their inherent responsibilities for existent and abandoned sites. However, these steps or phases with their respective aerial photographic needs can be applied whether the investigation takes the form of compliance monitoring/enforcement, preliminary assessments, remedial investigation/feasibility study or remedial action and subsequent monitoring.

A project usually begins with receipt of a project request. A written or oral request is usually given which includes details such as location, site history, accessibility, and other important specifics that influence and define a project plan. At this early stage of the project, use of aerial photography should be considered.

After a project is requested, a background review is conducted to collect informati uch things as existent literature, pertinent federal and state files, an strategies. This information will be used in project plan formulati sted below is information needed for including aerial photographs and/or photo analysis in enforcement projects.

- Enlargements for field work
- Specific features to be identified in photo analysis

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LOCKHEED
EMPLOYEES
ORGANIZATION

- Use of current and/or historical photographs
- Inclusive dates for study period
- Specific dates for historical photocoverage
- Film type, photo scale(s), and time of photo acquisition
- Final deliverables

To obtain this information, coordination with EMSL-LV technical monitors would be desirable. Any published or unpublished data on the physical environment or hazardous waste operations at the study sites should be made available to EMSL-LV to assist in developing the history of significant features.

The project plan is usually a detailed outline based upon overall objectives and information provided by the requester. Part of this plan can include the intended uses of aerial photography in the project along with data on items listed in the background review phase. Schedules regarding photo acquisition and deliverable dates should also be included. These should be coordinated with EMSL-LV staff to assure timely delivery of products. Because aerial photography and its products can be used as planning tools, overflights and interim deliverables (enlargements for field work) should be completed prior to field survey work.

Actual project activities commence when plans have been finalized. EMSL-LV staff perform project tasks such as photo acquisition, preparation of contacts and enlargements, photo analysis, and final report preparation. In all phase activities strict chain of custody rules are employed preventing tamperin photo images or interpreted data. If desired, certain portions of the a can be verbally transmitted to the requester if there is an urgent requirement. Work flow is flexible to accommodate for any changes in requirements resulting from legal strategies or acquisition of new data on a site.

SECTION VI
ENFORCEMENT INVESTIGATION AND LITIGATION EXAMPLES

MONTROSE CHEMICAL PLANT
TORRANCE, CALIFORNIA

The Montrose Chemical Plant located in Torrance, California (Figure 1) began operations in 1947. In 1980 and 1981 elevated levels of DDT were detected in mussels in Los Angeles Harbor. Similar levels were also detected at various water quality stations located between the plant and the harbor. Based upon these data, the source of contamination was traced to the Montrose facility. Acquisition of aerial photographs, enlargements, and photo analysis were requested from EMSL-LV. Photo analysis techniques revealed a drainageway trending to the south away from the plant. Based upon this information, Region 9 personnel devised a sampling plan to determine extent of contamination. After the next storm event, DDT levels were found to be greatly elevated along the drainageway.

Several old waste disposal areas were observed on historical photocoverages by EMSL-LV personnel. These areas changed in size and shape from one photocoverage to another. This information was presented on an enlargement of a current photo. This display allowed Region 9 personnel to observe change in these areas throughout the study period and was used to develop sampling plans. The approximate locations of the waste areas are depicted on Figure 1 with the photocoverage date which they were first observed.

Because of the extent of contamination, the site was included on the Superfund National Priorities List. Also, photo enlargements were used to brief EPA personnel participating in investigations and in public meetings to brief nearby residents on existent problems at the plant. As a result of investigations and administrative rulings, Montrose was ordered to cease all manufacture of DDT and construct dikes to prevent surface waters from leaving the site. This site is now undergoing extensive site characterization during the remedial phase of the study.

Figure 1. Montrose Chemical Plant; Torrance, California; June 22, 1981. Scale 1:2,400.

BERLIN AND FARRO
GENESEE COUNTY, MICHIGAN

Liquid industrial wastes were incinerated at the Berlin and Farro site in Michigan (Figure 2) from 1971 to 1980 with no controls on emissions. Unpermitted lagoons were used for storage of sludges and liquids. Crushed and empty 55-gallon drums were buried in an on-site landfill. Toward the end of the 1971 to 1980 period, full drums were being buried. Liquids containing C-56 (a pesticide by-product) were found onsite and traces of the by-product were detected in nearby streams. The site was closed in 1980 and by 1982 removal of contaminated earth, liquids, sludges, and drums was completed.

Historical analysis of photography covered the years prior to initiation of plant operations through the present. A 1972 aerial photograph depicted surface drainage prior to establishment of operations. Knowledge of the surface drainage prior to alteration proved useful in this case since it was determined through field investigation that seepage from the lagoons flowed along an old natural drainageway beneath the lagoons. Photographs dated in 1978 (Figure 2) revealed the two unpermitted lagoons and a waste incinerator. A large amount of soil disturbance was visible at the site suggesting ongoing burial activity.

The 1978 photograph with photointerpretive information and affidavits by former employees were used to establish the fact of illegal burial and substantiate the location of such activity. Search warrants were issued based upon this information. An EPA geophysical team was allowed onsite and through use of magnetometer and radar devices located the buried drums. This example illustrates that interpretive information derived from aerial photos can reveal a need for further onsite investigation to confirm analysis results and further define environmental problems.

Figure 2. Berlin and Farro Site; Genesee County, Michigan; August 21, 1978. Scale 1:4,800.

FMC COKE PRODUCTION PLANT
KEMMERER, WYOMING

In 1960, an experimental coke manufacturing plant was constructed near the town of Kemmerer, Wyoming (Figure 3). Sometime between 1969 and 1972 the plant went into full production. It produces approximately 100,000 tons of coke per year. Several impoundments on the site were determined to be leaking into ground-water acquifers. These impoundments contain phenolic compounds. Additionally, no operational ground-water monitoring program had been established at the plant. Color photography was flown in June of 1983, and photo analysis performed. Two important facts emerged. A clean water pond not mentioned in the original RCRA permit application was discovered north of the main plant processing area. This turned out to be the primary water source for the plant. Also, a large solid waste area whose exact extent was not determinable from field investigations was measured on the photos and viewed in its correct relationship to other parts of the operation. Historical aerial photographs were obtained and investigators noticed a significant reduction in the amount of solid waste in the solid waste disposal area. When questioned, the plant operators stated that they had been dumping it into a tarry water pond to the south. This, activity may lead to further contamination of subsurface waters and adds to the difficulty of detecting soil contamination. The owners have altered their waste disposal operations and will close the tarry water pond. Remedial action for having a leaking surface impoundment has been sought. The legal case is still pending. The photographs were also used to brief EPA investigators and legal staff on the environmental problems present at this site. They could be used to file further actions with regard to potential groundwater violations at the facility. Region 8 enforcement staff use the photographs in case development and as valuable visual aids in court.

Figure 3. FMC Coke Production Plant; Kemmerer, Wyoming; May 23, 1983. Scale 1:8,400.

SEYMOUR RECYCLING CORPORATION
SEYMOUR, INDIANA

The Seymour Recycling Corporation site (Figure 4) is located south of the town of Seymour, Indiana. It is an abandoned industrial waste reclamation operation. Chemical and solvents such as phenols, cyanides, acids, and C-56 were left onsite in 55-gallon drums and bulk storage tanks. Operations began in 1969 and the facility was sold in 1978. By 1979 because of numerous permit violations, the site was closed. In 1978, color aerial photography was acquired and a drum count was conducted. The number of drums was estimated at 50,000-60,000. The actual count (as well as could be ascertained due to mass drum staging) was 48,000-50,000. In 1983, maps were made of the 1979 photos and later imagery for a variety of uses. These include:

- Congressional hearings
- Courtroom proceedings
- Public hearings and investigatory briefings
- Discussions with site owners
- To locate position and orientation of ground photos

Currently a feasibility investigation is underway to determine clean-up alternatives.

Figure 4. Seymour Recycling Corporation; Seymour, Indiana; November 6, 1980.
Scale 1:2,240.

HUSKY OIL REFINERY
CODY, WYOMING

This facility (Figure 5) is located adjacent to the Shoshone River in Cody, Wyoming. This refinery was shut down in 1982 but no required closure plan was submitted to EPA. The hazardous waste management area is located east of Cottonwood Creek. Waste management has been ongoing since 1975 and consists of a landfarm, landfill, and two lagoons. Oil sludges are placed on the landfill. An improper well monitoring system had been established that failed to adequately assess possible ground-water contamination at the site.

Because of the inadequate monitoring system and failure to submit a closure plan, EPA filed a compliance complaint order. Aerial photo enlargements were obtained from EMSL-LV and were used to detect microgradients (which in this instance were indicative of direction of ground-water flow) and as a briefing tool during site investigations and negotiations with Husky representatives.

An out-of-court settlement was obtained specifying times and methods of site clean up and assessment of fines and penalties. The refinery west of Cottonwood Creek is being closed and the hazardous waste management area to the east of the creek is undergoing a hydrogeological study to determine the possible extent of ground-water contamination from the regulated units. Another problem, a petroleum source leak, that occurred in the past in the main portion of the refinery was recently discovered and photographs will be used to select potential monitor well sites to gain a further understanding of the problem and provide assistance in developing remedial action plans.

EPA Superfund personnel are now using the aerial photographs to search for old areas of disturbed ground where former waste disposal may have occurred. After locating these old areas, the photos will be further used to plan ground sample strategies.

Figure 5. Husky Oil Refinery; Cody, Wyoming; May 23, 1983. Scale 1:6,000.

KOPPERS COMPANY
TEXARKANA, TEXAS

The Koppers Company facility was a creosote plant located immediately south of Texarkana, Texas (Figure 6). The plant began operations in 1903 and was dismantled in 1961. As a result of these operations, the old cooling ponds, drip tracks, and process area contained hazardous chemicals. In the late 1960's, the Carter Terrace subdivision was constructed on the northern half of the Koppers site. Because of potential problems, the site was put on the National Priorities List in 1984. After a series of complaints from Carter Terrace residents, emergency response teams were sent to the site. EMSL-LV analyzed current and historical photographs locating the contaminated areas. The locations of contaminated areas seen in 1954 were transferred to line maps depicting current conditions. This information allowed the emergency response teams to locate sampling areas where contaminants would be found. Several backyards were sampled and polynuclear aromatic hydrocarbons (PAH) and hecta-hepta-octa-isomers were found. As a result of this, a CERCLA administrative order was issued and a long-term remedial investigation feasibility study was initiated. The maps discussed above also helped in the design of this study which is in progress at this time.

Figure 6. Koppers Company; Texarkana, Texas; September 5, 1984. Scale 1:4,200.

HUSKY OIL COMPANY
CHEYENNE, WYOMING

The Husky Oil Company refinery (Figure 7) is located in Cheyenne, Wyoming, adjacent to Crow Creek. In June of 1981 a routine RCRA inspection revealed seepage from two unlined lagoons containing liquid hazardous waste substances in the southeast portion of the property. This seepage eventually flowed into Crow Creek. At that time, the company was notified to take remedial action. The remedial measures were not implemented and in June of 1983 EPA issued a compliance complaint order under Section 3008 of RCRA. Color aerial photography was flown in July of 1983. Subsequent photo analysis revealed the seepage emanating from the lagoons and entering a nearby drainage canal which flows into Crow Creek. Enlargements with interpretive overlays were used in settlement negotiations.

Graphic portrayal of the lagoon seepage aided in a resolution of the case in June of 1984. The company agreed to empty the two lagoons and also dispose of contaminated soil. At a later date the ponds will be lined to prevent seepage and to meet permit standards.

If no settlement had been reached, EPA would have used the photos in subsequent administrative hearings or litigation.

Figure 7. Husky Oil Company; Cheyenne, Wyoming; July 12, 1983. Scale 1:1,700.

GARY REFINERY
FRUITA, COLORADO

This refinery (Figure 8) is located on the north bank of the Colorado River in Fruita, Colorado. An initial inspection in November of 1981 and subsequent inspections by state personnel revealed eight separate violations. The most important of these was an inadequate ground-water well monitoring system. Color aerial photography was acquired in May of 1983 and used to locate a proposed monitoring well network and to gain an overall perspective of the locations of impoundments, waste pits, and hazardous waste management units. In April of 1984 a Compliance Complaint Order was issued under Section 3008 of RCRA. Negotiations are still ongoing between refinery owners and EPA representatives. Aerial photos are also being used in these negotiations. The company has recently filed for protection under Chapter 11 of the Federal Bankruptcy Code.

Figure 8. Gary Refinery; Fruita, Colorado; May 21, 1983. Scale 1:8,400.

LOWRY LANDFILL
ARAPAHOE COUNTY, COLORADO

This landfill (Figure 9) is located approximately 15 miles southeast of Denver, Colorado. Burial of hazardous wastes began at the site in 1966. However, by 1980 migration of contaminated ground water was detected. In 1983 EPA initiated an enforcement action against the City of Denver and in 1984 the site was placed on the NPL. Analysis of historical photographs by EMSL-LV revealed old pits and trenches that had been filled with hazardous waste and buried under 25-50 feet of municipal refuge.

The symbols "P" and "T" with appropriate photocoverage years are used to illustrate locations of these burial pits and trenches. By knowing the locations of these features, detailed ground study of their contents and extent of pollutant migration could be determined. An out-of-court settlement was achieved that resulted in interim remedial measures. An underground barrier wall was constructed north of the site. To prevent off-site ground-water migration a treatment system for contaminated ground water was also installed.

Drainage delineations obtained from the aerial photographs formed the basis of the design of altered surficial water flow. EMSL-LV has completed a detailed topographic map of the site.

At present EPA is conducting a Superfund-financed remedial investigation/ feasibility study. The first phase of the field work has been completed; it included installation of well points into the waste pits that were identified using the historical photography described above.

Figure 9. Lowry Landfill; Arapahoe County, Colorado; June 21, 1984. Scale 1:8,000.

RAILROAD SITE - UNION PACIFIC
LARAMIE, WYOMING

The Union Pacific Railroad site (Figure 10) in Laramie, Wyoming, has been in existence since approximately 1880. The plant started upgrading a creosote process in the 1920's and the wastes were typically discharged to various ditches, sloughs, and low-lying areas. The process using pentachlorophenols was started in 1956. In 1958, four surface impoundments with a capacity for five million gallons were excavated from the alluvium. An inspection in 1981 revealed leakage from the impoundments, contaminated soils and potential flooding problems. In 1983, the site was listed on the NPL. Negotiations with Union Pacific and subsequent litigation followed. Color aerial photographs were acquired in May of 1983 and a detailed topographic map was also constructed. In court, enlargements of the site were used to show the spatial relationship of the waste ponds to the Laramie River floodplain. The topographic map was used to illustrate the location of the 100-year flood contour thus demonstrating the actual threat of flooding and transport of the hazardous waste into the river.

This case was settled out-of-court; the surface impoundments were cleaned up under a partial RCRA closure. Union Pacific is completing RIS/FS and identifying alternatives for cleanup of the entire site.

Figure 10. Union Pacific Railroad Site; Laramie, Wyoming; May 23, 1983. Scale 1:8,400.

BURLEY LAGOON
PIERCE COUNTY, WASHINGTON

Based upon an informant's disclosure, EPA Region 10 personnel suspected that a nonferrous metal scrap salvage operation was present in a relatively isolated area behind an old car junk yard located near Burley Lagoon (Figure 11). The operation was observed in 1982 on aerial photographs flown for another EMSL-LV project. Historical photos available to Region 10 personnel were used to determine approximately when the operation had begun. Analysis of photography revealed locations of various types of machinery, oil stains, and fill material. Analysis of color infrared photos revealed two drainageways leading from the salvage operation to Burley Lagoon, a prime oyster rearing area. The area is heavily wooded and observation was difficult so oblique photos were acquired in an attempt to observe under certain trees that were around the perimeter of the site. The exact extent of a large oil stain was thus detected. Using this information a search warrant was obtained and EPA personnel went onsite. All the machinery observed on the photographs was present and the dark stained area had been covered with fill material. The operator had been selling old transformers for scrap metal and old PCB-laden oil to an oil reclamation firm. He also burned a small amount of it and sprayed some on the access road for dust supression. Results of this case are still pending.

The most important overall value of the aerial photographs was that their use allowed inspection of the site prior to onsite inspection so that evidence could be gathered to justify a search warrant.

Figure 11. Burley Lagoon, Pierce County, Washington, June 13, 1984. Scale 1:2,350.

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